# THE BIRTH OF SATELLITE COMMUNICATIONS

**Twenty-five years ago worldwide communications entered a new era. Telstar, the world's first commercial communications satellite, was launched on July 10, 1962, and the first live television signals via satellite were received by British Telecom's Goonhilly earth station in the early hours of the following morning.**

In October 1945, the magazine *Wireless World* published an article by Artur C. Clarke, today probably better known as the autor of *2001—A space Odyssey*, entitled *Extra-terrestrial relays—can rocket stations give worldwide radio coverage?*

Arthur C. Clarke commented in his article: "Many may consider the solution proposed in this discussion too farfetched to be taken very seriously." Yet his idea was to prove the blue-print for today's satellite communications network.

He accurately predicted the orbital velocity that a rocket would need to become an artificial satellite, or second moon, circling the world with no expenditure of power. He also predicted that a satellite circling the earth above the equator at a certain height would appear to be stationary to the earth and that three such satellites could give global radio coverage.

He further predicted that development of rocket technology, started by the Germans during the second world war, would soon make it possible to place a satellite in orbit.

Today, reality has caught up with science fiction as British Telecom International-BTI-handles more than three million minutes of telephone calls, television pictures, data, facsimile, and telex, every day through Goonhilly and its other intercontinental links.

About 90 per cent of the world's telephones—some 600 million of them—in 173 countries can be dialled direct from the UK. Telephone services are provided to more than 200 countries and each day more than 500,000 calls are connected from the UK to the other countries.

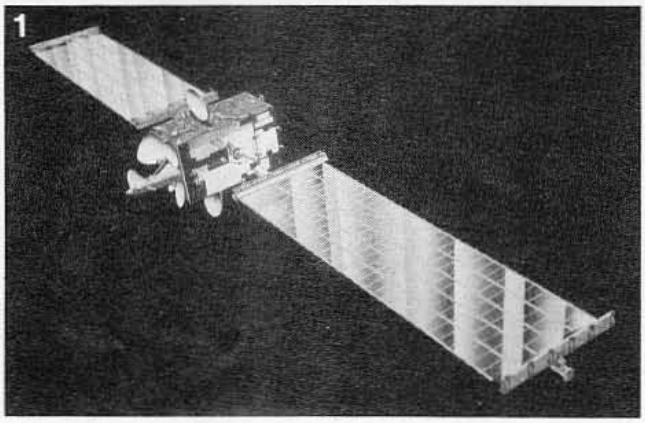


**Fig. 1. The Olympus satellite is one of the largest and most powerful in the world.** ***Photograph courtesy of British Aerospace.***

## The early Telstar demonstrations and tests

In the Spring of 1961 it was jointly announced in the United Kingdom, the USA and France that the US National Aeronautics and Space Administration (NASA), the French Centre for Telecommunications Studies and British Telecom, as its predecessor Post Office Telecommunications, would cooperate in a programme for transatlantic testing of communications satellites.

At the same time it was announced that satellite earth stations would be built in England and France "for the reception and transmission of telephone, telegraph and television signals across the Atlantic using satellites to be launched by NASA during 1962 and 1963."

Work began shortly afterwards to build the UK's first satellite station at Goonhilly Downs in Cornwall. The site was chosen because it was as far west as possible to obtain the maximum period of visibility to the United States via the satellite, to be remote from sources of electrical interference, and to provide an onobscured view to the horizon for the longest possible contact with the satellite.

In less than a year from gaining access to the site the station was ready. A massive, steerable dish antenna, weighing 870 tonnes with a 25.9m dish had been built. All of the equipment on the station was of British design and manufacture, with the exception of one American transmitting klystron valve.

The British design was the odd-man-out among the three earth stations to be used for the tests. Both the American station at Andover, Maine, and the French station at Pleumeur Bodou in Britanny were equipped with horn antennas housed in radomes. The British station had cost around £800,000 to complete, about a quarter of the cost of the American and the French stations.

In early July 1962 it was announced that Telstar would be launched from Cape Canaveral on either July 10 or 11.

The successful launch took place at 8.35 GMT on Tuesday, July 10, and the desired orbit was achieved. With Telstar circling the earth at heights varying between 590 and 3500 miles, it was possible to achieve three or four periods during each 24 hours when mutual visibility between Goonhilly and Andover lasted for 30 to 40 minutes.

During these periods the antenna at Goonhilly had to be accurately manoeuvred to follow the satellite from the moment it rose above the horizon until it again disappeared from view. The signal transmitted from the antenna to the satellite was con-

**Fig. 2. A small section of Goonhilly Downs Earth Station: in the foreground Aerial No. 7.** ***Photograph courtesy of British Telecom.***

centrated into a narrow beam, one-fifth of a degree in width, so absolute precision was necessary. To maintain this accuracy in high wind meant that the antenna had to be massive and sturdy. In order to move the antenna so accurately it was equipped with electric motors of some 100 horse power. However, the engineering design resulted in such good balance and smooth movement of the antenna that normaly less than two horse power was required under reasonable weather conditions.

The primary purpose of the Telstar satellite tests was to acquire data on which to base the future design of satellite systems for commercial operation. However, during the period from July 10 to July 27 a number of demonstrations were carried out which illustrated the potentialities of satellite systems for world-wide telecommunications.

In the early hours of July 11 the first usable orbits were the sixth and seventh and the first attempt at television reception was made. Reception was decidedly poor. Some experts were quick to blame Goonhilly's unique antenna design, and *The Times* described the experiment as "an almost total failure". Some experts said the antenna was too heavy and cumbersome to accurately track the satellite, others blamed the driving mechanism. The problem proved to be that one component had been fitted the wrong way round and it was a twenty-minute job to correct it. The effect of the incorrect fitting had been to reverse the direction of the wave polarization of the antenna, relative to that of the satellite, introducing a serious weakening of the strength of signals received. The problem arose because of an ambiguity in the accepted definition of the sense of rotation of radio waves; a difficulty which had been encountered both in the USA and the UK in the period just before the tests. With the correction made, excellent pictures were received on orbit 15 during the evening of July 11, and during orbit 16 the first live television transmission between Europe and the USA was made from Goonhilly to Andover. The pictures and sound received at Andover were reported to be of excellent quality and were broadcast as received throughout the USA.

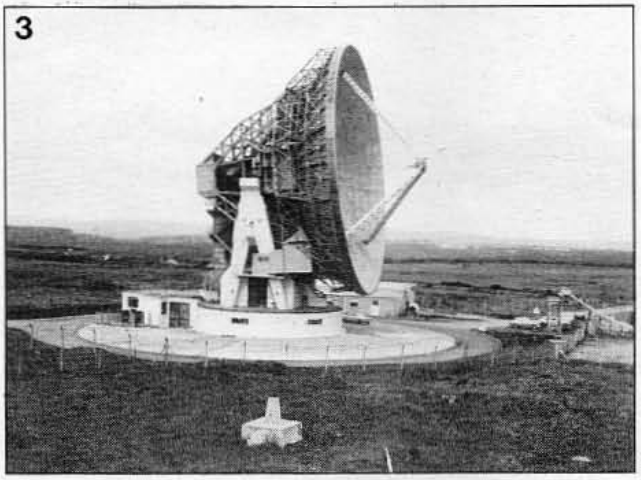


Fig. 3. The first of the dish antennas to be installed at Goonhilly Downs. *Photograph courtesy of British Telecom.*

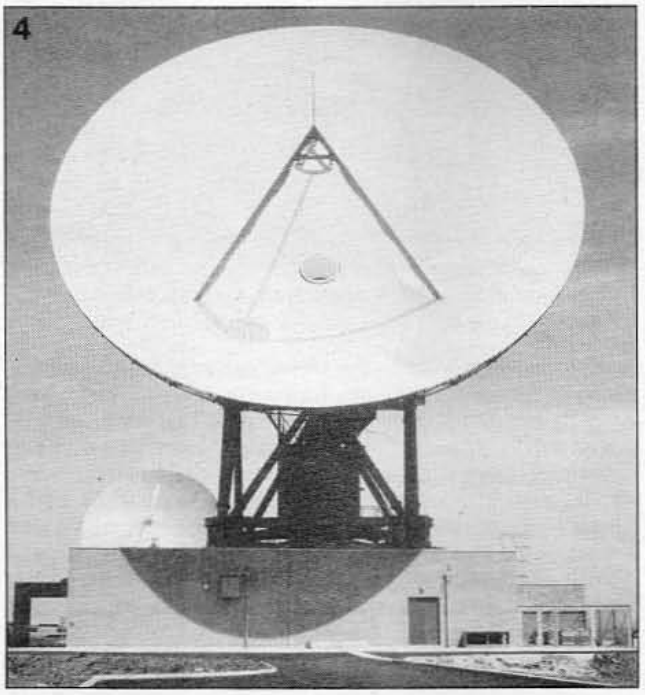


Fig. 4. Aerial 6 is Goonhily's largest dish with a diamter of 32 m. It was also the first "dual frequency" antenna, able to transmit and receive on two different frequencies simultaneously. *Photograph courtesy of British Telecom.*

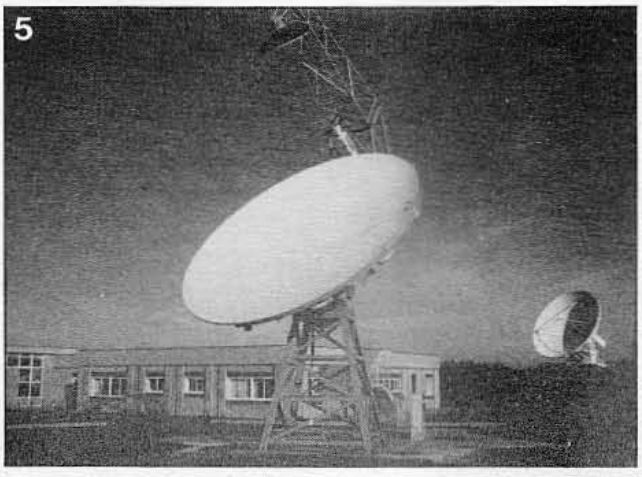


Fig. 5. The latest of the antennas (No. 10) to be installed at Goonhilly Downs. *Photograph courtesey of British Telecom.*

On July 12 the first two-way transatlantic telephony tests were made, showing that good-quality, stable telephone circuits with low noise levels had been achieved. These tests were to be followed two days later by the first transatlantic telephone call and photo-telegraphy (facsimile) transmission via satellite.

On July 14 during orbit 34, the director general of the Post Office, Sir Ronald German, spoke from his home in London to the president of American Telephone and Telegraph Co (AT&T), Mr. Eugene McNeely, in New York. Simultaneously, one pair of channels was used to send facsimile pictures between London and New York.

On July 15 tests to assess the ability of a communications satellite to carry large numbers of telephone circuits were carried out during orbit 43. These demonstrated that at least 600 first-grade international circuits should be possible by satellite.

The first transmissions of colour television signals by satellite were made from Goonhilly during orbits 60 and 61 on July 16. With the co-operation of the BBC's research and designs department, who provided a colour slide scanner and monitor equipment, the signals, on 525-line NTSC standards, comprised captions, test cards and still pictures to assess colour quality. The transmissions were initially made from Goonhilly to the satellite and back to Goonhilly but were also received in Andover. Andover reported: "Colour—good; picture quality—excellent".

During orbit 87 on July 19 satellite communications were opened up to the press. Twenty-four calls were made by the British press from Fleet Building in London, to the American press in New York.

On July 23 during orbit 125 an 18-minute long programme from the European Broadcasting Union was transmitted from Goonhilly to Andover. The programme consisted of scenes from many European countries and was transmitted by the Eurovision link to Goonhilly, from Goonhilly to the satellite, and was received at Andover and broadcast throughout the USA.

During orbit 151 on July 26, the Telstar link between Goonhilly and Andover was used to provide telephone circuits for the US Information Agency involving conversations between "notable persons" in 20 pairs of cities in the USA and Europe for the Agency's "People-to-People" programme. The circuits were reported as excellent.

The Telstar tests confirmed that communications satellites could provide high-quality, stable circuits for television and multi-channel telephony. The performance of Goonhilly earth station was reported as excellent in every respect, and the equipment, almost all of which was of a unique new design, had worked well. In fact, Goonhilly's antenna design was to prove, as had Arthur C. Clarke's idea, to be the blue-print for the future.

## A brief history of Goonhilly satellite earth station

The choice of Goonhilly Downs, on the Lizard Peninsula in Cornwall, as the site of the United Kingdom's first satellite earth station, was made for exactly the same reasons that Guglielmo Marconi chose the Lizard for his pioneering work in maritime and international "wireless" telegraphy. The Lizard offers an uninterrupted view across the Atlantic and little electrical interference.

The first transatlantic wireless message was sent from the Lizard on December 12, 1901. Three faint but discernible "dots" of the Morse letter "S" were sent from Marconi's transmitter at Poldhu and received by him in Newfoundland, Canada. A year later Poldhu sent a signal to the vessel *Philadelphia* more than 2000 miles away in the ocean. Long-distance telecommunications had been born.

Sixty years later the advance of technology had made satellite communications, first proposed by the author and scientist Arthur C. Clarke in 1945, a realistic possibility. The United Kingdom, the USA and France announced in 1961 that they would co-operate in a programme for the transatlantic testing of communications satellites.

The search for a suitable site in the UK for the station that would receive the signals from the satellites, ended in the Lizard, on the flat expanse of Goonhilly Downs.

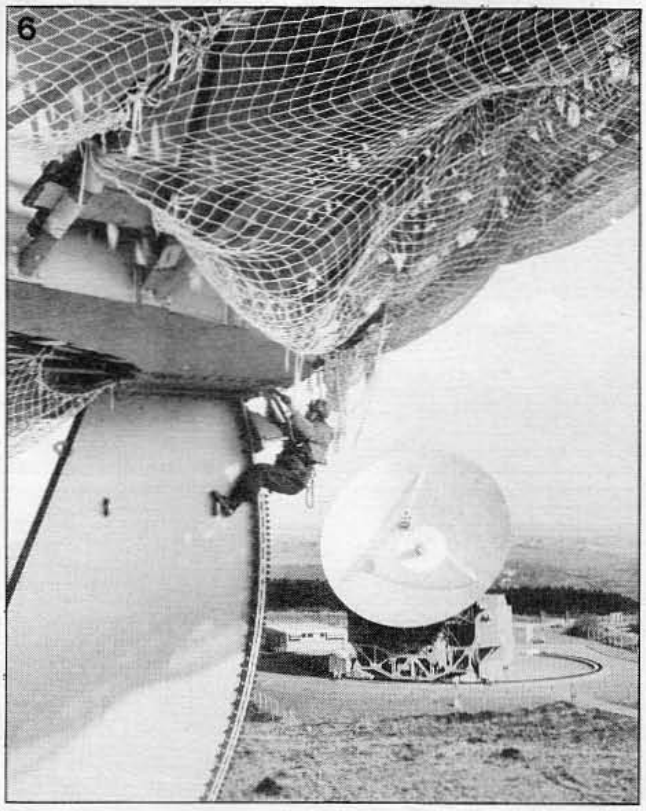

Fig. 6. A British Telecom rigger examines the steelwork of Goonhilly Eart Station's antenna No. 6. *Photograph courtesey of British Telecom.*

The Lizard offered an unimpaired view of the Atlantic horizon, giving the longest possible contact with the low-orbiting satellites then being used. It suffered from little electrical and radio interference; was well placed to connect with inland communications, power supplies and transport links; and had a climate with moderate rainfall, little seasonal variation in temperature and only occasional snow.

Equally important was the geology of the area. The serpentine bedrock reaching a thousand feet deep would give vital support to the massive weight of the antennas.

Within a year of obtaining possession of the site, the first antenna, the control room and its associated equipment were installed and ready for the first tests which would use the Telstar satellite, to be launched by the US National Aeronautics and Space Administration (NASA) on July 10, 1962.

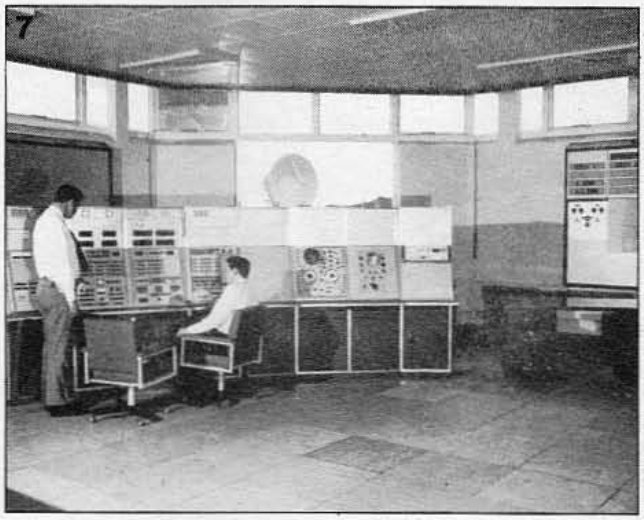

Fig. 7. A section of the control area at Goonhilly Downs. *Photograph courtesey of British Telecom.*

Those tests confirmed that satellites could have a commercial future in international communications. During a period of 16 days several world-firsts went into the record books—the first live television transmission between Europe and the USA, and the first telephone calls, facsimile transmission and transmission of colour television by satellite.

Because of the low orbit of Telstar—between 590 and 3500 miles above earth—the satellite was only usable for three or four 30-to-40 minute periods in each 24 hours. As the satellite raced across the sky from horizon to horizon, the antenna had to be nimble enough to follow the satellite to one-fifth of a degree's accuracy during each of these brief visits.

Aerial 1 at Goonhilly was a unique design - an 870 tonnes "dish" antenna, compared to the French and American horn antennas enclosed in radomes. Some initial problems during the first usable orbits of Telstar caused experts to blame the design of the British antenna, but a small problem with a component which had been fitted faultily proved to be a twenty-minute job to correct and the antenna then went on to establish its world-firsts.

Goonhilly Station had cost around £800,000 to complete, about a quarter of the costs of the American and French stations, and it was the unique design of the British dish antenna which was to go on to become the norm for satellite communications throughout the world. The dish design is now used generally by nearly 700 satellite stations in more than 150 countries.

Following the successful tests with Telstar an international satellite organisation was set up in August 1964 - INTELSAT. Interim agreements were signed by 11 member nations - the USA, UK, Canada, Denmark, France, Italy, Japan, the Netherlands, Spain, the Vatican City State and Australia. Today INTELSAT is owned by more than 100 member countries.

INTELSAT launched its first satellite into orbit in April 1965. The satellite, INTELSAT I, known as *Early Bird*, was a

high-orbiting satellite in "geostationary orbit".

Arthur C. Clarke had proposed in his 1945 paper that satellites, circling the earth above the equator at a certain height, would appear to be stationary to the earth's surface—their period of orbit would exactly match that of the earth's natural rotation. That distance was 22,300 miles above the equator.

After INTELSAT I's successful launch to this height, commercial service opened in June 1965.

Arthur C. Clarke had also proposed that three satellites in geostationary orbit could give world-wide radio coverage.

A second satellite—INTELSAT II—was launched in December 1966, and at the same time, Aerial 1 at Goonhilly, which now no longer needed to track low-orbiting satellites across the sky, had an extra reflecting surface added, pushing its weight up to 1100 tonnes.

Satellite communications had now truly entered commercial operation. As the demand for transatlantic TV and telephone transmission grew, so did Goonhilly with the addition of Aerial 2 in 1968.

By 1969 three geostationary satellites were in orbit, fulfilling Arthur C. Clarke's prophesy of global communications. INTELSAT III was positioned above the Indian Ocean and demand for satellite communications with the Far East grew. To meet this need Aerial 3 was brought into service in 1972.

Aerial 4 was added in 1978, to meet an ever-increasing demand for communications across the Atlantic. This was also one of the first antennas in the world to use the 11/14 GHz frequency as soon as it became available for business satellite communications.

Demand for satellite communications grew by 20 per cent a year during the 1970s and early 1980s. Further satellites were put into orbit and in October 1978 a second earth station was brought into service by British Telecom at Madley in Herefordshire.

Demand for specialist sevices also grew during this period and in 1983 Aerial 5 at Goonhilly was completed to provide satellite services to ships at sea.

At the same time Aerial 6 was being built to provide further capacity on the busy transatlantic route. Aerial 6 is Goonhilly's largest dish with a diameter of 32m. It was also the first "dual-frequency" antenna, able to both transmit and receive on two frequencies simultaneously—doubling potential capacity. It entered service in September 1985.

Fig. 8. Children from a nearby primary school being shown a model of the Intelsat V satellite. *Photograph courtesy of British Telecom.*

While aerial 6 was being built, Aerial 7 was also being brought into service to provide leased TV services to North America.

With continuing growth in demand for satellite communications, British Telecom announced plans in August 1983 to built a third earth station in London's Docklands, primarily for satellite TV distribution and specialised business services. The London Teleport, in North Woolwich, opened for operation in February the next year—less than six months after site clearance began.

Aerial 7 at Goonhilly, initially used for TV circuits, is now being used for the trial of *Skyphone*—a telephone service to aircraft in flight—which is due to start by the end of this year.

Fig. 9. The antennas are painted regularly: each one takes a 1000 gallons of marine paint and two full seasons' painting. *Photograph courtesy of British Telecom.*

Meanwhile Aerials 8, 9 and 10 have been built. These are small-dish antennas below 14m in diameter. They are used for research and development, and to provide monitoring and control facilities on the more than 130 satellites currently in use.

Today, development at Goonhilly continues. Aerial 6, the biggest antenna, has been equipped to operate to the latest development in satellite communications—Time Division Multiple Access/Digital Speech Interpolation (TDMA/DSI). TDMA/DSI means that signals from the station are grouped and sent by time rather than frequency, so that, on the principle that during the average telephone conversation either party is only speaking for one third of the time of the call, other groups of signals can be sent along the same channels during the lapses of conversation

While British Telecom's earth station at Goonhilly provides vital links for today and tomorrow, it has not forgotten its past—a past that goes back far beyond Marconi's early experiments.

The Lizard Peninsula is designated as an Area of Outstanding Natural Beauty and Goonhilly Downs was Cornwall's first National Nature Reserve. In developing the earth station, British Telecom spent £200,000 landscaping the scheme to form natural-looking mounds, or bunds, inside and outside the station's boundaries. Local heathers, gorse and willow were planted in the station, in keeping with the natural character of the Downs. With little intrusion from the public, amidst the silent giants of Goonhilly's antennas, the local flora and fauna have been able to flourish, making Goonhilly not only a pioneer in high-technology but also a botanist's paradise.